Fisheries Oceanography of Yellowfin Tuna (*Thunnus albacares*) in the Tasman Sea

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Cover illustration of yellowfin tuna, *Thunnus albacares*, by Roger Swainston © CSIRO Marine Research, Australia

Abstract

Sustainable fishing is required to protect and maintain marine biodiversity and to ensure fisheries that are both economically viable and productive. Effective management of living marine resources requires well-informed decisions through an appreciation of past, present and future pressures. Understanding "why fish are caught where they are?" is the oldest question in fisheries research and is a central issue for the sustainable catch, management and conservation of marine resources. Here we look at the Australian longline fishery to better understand where yellowfin tuna (*Thunnus albacares*) are caught on the hooks set by the eastern tuna and billfish fishery (ETBF) in the Tasman Sea. We view the catch of this species in the context of the recent oceanography of the Tasman Sea, sixty years of fishermen's knowledge and experience, a future climate scenario, declining stocks of other large pelagic predatory fish and an increasing demand in products derived from these species.

The physical environment directly influences the distribution, abundance, physiology and phenology of marine species. Relating species presence to physical ocean characteristics to determine habitat associations is fundamental to the management of marine species, however, direct observation of highly mobile animals in the open ocean, such as tunas and billfish, is challenging and expensive. As a result detailed data on habitat preferences using electronic tags has only been collected for the large iconic, valuable or endangered species. An alternative is to use commercial fishery catch data matched with historical ocean data to infer habitat associations. Using catch information from an Australian longline fishery and Bayesian hierarchical models we investigate the influence of environmental variables on the catch distribution of yellowfin tuna (Chapter 2). The focus was to understand the relative importance of space, time and ocean conditions on the catch of this pelagic predator. We found that pelagic regions with

elevated eddy kinetic energy, a shallow surface mixed layer and relatively high concentrations of chlorophyll *a* are all associated with high yellowfin tuna catch in the Tasman Sea. Time and space information, while important, were less informative than oceanic variables in explaining catch. An inspection of model prediction errors identified clumping of errors at margins of ocean features, such as eddies and frontal features, which indicate that these models could be improved by including representations of dynamic ocean processes which affect the catch of yellowfin tuna.

We use the same catch prediction model to consider where yellow fin tuna catches may occur in the context of a future climate scenario (Chapter 3). We used output from a global climate model (GCM) from the IPCC 2007 AR4 summit to produce predictions of surface ocean characteristics for the Tasman Sea in the 2060s. These data were used to initialize a biogeochemical model to create an ocean productivity product for the surface ocean that was equivalent to the chlorophyll *a* concentration as estimated by the ocean color SeaWiFS product. We use these products as inputs for the YFT catch prediction model to determine where YFT may be caught in the Tasman Sea in 2060s. We compare these predictions to those from the 1990s and the 2000s to show how the pattern of modelled YFT catches differ from those estimated by the model for the earlier time periods. Identifying possible shifts in the availability of YFT to commercial longlining over such long time period inform the construction of long-term goals upon which strategies for resource management; coastal infrastructure development and fleet management can be considered. This approach can also be applied at shorter time scales if biogeochemical downscaling is available.

Successful sustainable management of living marine resources can occur when the enhanced details of the resource, industry and market are thoughtfully integrated into the planning and implementation of management strategies. Engaging the fishing community

in the management process is a proven approach to the successful implementation of management strategies with sustainable outcomes. We report on a 2006 survey of the ETBF which recorded the perspectives of the resource users and cooperative managers regarding the location and catch of YFT in the Tasman Sea (Chapter 4). We show that the fishing community hold varied perspectives on the most influential ocean characteristics with respect to YFT catch and show how perspectives relate to the fishing region. Further work collecting, analysing and incorporating the opinions and knowledge of the fishermen of the ETBF into habitat and catch models is recommended as a direction for future work. Utilizing the qualitative information from fishers would minimise biases in the catch information, associated with the multispecies targeting and markets prices, and encourage better collaboration between fishermen, scientists and management for the sustainable future of the resource and fishing community of the east coast of Australia.

Overall, the work presented here show that YFT catches in the Tasman Sea can be partially explained by variation in the surface ocean environment. To achieve this goal, we used machine learning techniques to identify the most informative variables from the available ocean data and used a generalized linear model based on a hierarchical Bayesian framework to characterise the relationship between these variables and YFT catch. These techniques have not previously been used for this purpose in the Tasman Sea. The algorithms and model structures employed here provide a valid alternative to conventional habitat modelling techniques.

Declaration of Originality

This thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, except by way of background information and duly acknowledged in the thesis, and to the best of my knowledge and belief no material previously published or written by another person except where due acknowledgement is made in the text of the thesis, nor does this thesis contain any material that infringes copyright.

Statement of Ethical Conduct

The research associated with this thesis abides by the international and Australian codes on the inclusion of human interactions in research. This research was conducted subject to the approval and guidelines of the Human Research Ethics Committee (Tasmania : reference H0008690).

James Dell 29 November 2012

Statement of publication and co-authorship

Publications produced as part of this thesis:

Dell, J., Wilcox, C.V. and Hobday, A.J. (2011) Estimation of yellowfin tuna (*Thunnus albacares*) habitat in waters adjacent to Australia's East Coast: making the most of commercial catch data. *Fisheries Oceanography,* **20,** 383-396.

Dell, J., Hobday, A.J., Chamberlain, M., Matear, R. and Wilcox, C.V. (in prep.) Potential impacts of climate change on the distribution of longline catches of yellowfin tuna (*Thunnus albacares*) in the Tasman Sea. *Climate Science*

Dell, J., Wilcox, C.V., Hobday, A.J. and Hindell M (*in prep.*) Fish Tales : can fishermen's expert knowledge improve models of tuna availability? (*Fish and Fisheries*)

Dell, J., Wilcox, C.V. and Hobday, A,J. (2007) *58th-**Tuna-Conference**-Proceedings.* Lake Arrowhead, California

Dell, J., Wilcox, C.V. and Hobday, A,J. (2007) Aiding the habitat characterization of pelagic predators using expert opinion. *Annual meeting for the Society for Conservation Biology*. Port Elizabeth, Eastern Cape South Africa

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We the undersigned agree with the above stated "proportion of work undertaken" for each of the above published (or in preparation) peer-reviewed manuscripts contributing to this thesis.

James Dell (Candidate)

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